

THE DESIGN OF A BEACH PROFILER(U) VMI RESEARCH LABS  
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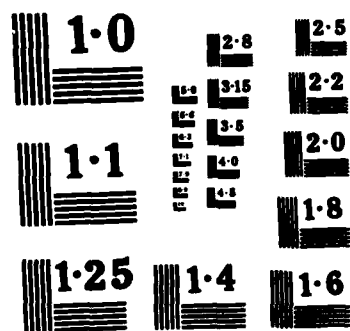
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NL

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FIGURE 1

DATE



NATIONAL BUREAU OF STANDARDS  
MICROCOPY RESOLUTION TEST CHART

AD-A157 715

# THE DESIGN OF A BEACH PROFILER

R. A. ERCHUL

JUNE 1985

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THE  
DESIGN OF A  
BEACH PROFILER

R.A. Erchul

June 1985

Sponsored by:

Office of Naval Research  
800 North Quincy Street  
Arlington, VA 22217



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## Abstract

Three designs of a beach profiler system were designed by VMI cadets as a part of requirements in the VMI's course "Coastal Engineering." All the systems were designed to measure the water depth in the surf zone to within  $\pm$  one foot accuracy under all weather conditions. All system designs used a pressure sensor to measure depth, however, each varied in method of employing this sensor. Two of the designs propelled the sensing unit sub-system while the third design used a push-pull method of employment. The distance of employment into the surf zone varied from 300 to 3,000 feet. The designed systems were fairly economical in cost ranging from \$2,020.00 to \$4,348.00. Projected scenarios of operations varied in the systems used requiring from one to six personnel for employment.

## Introduction

The goal of this proposed research was to design a beach profiler that would accurately and rapidly provide the bathymetric profile in the surf zone under all weather conditions. In order to accomplish this task the principal investigator organized and provided the design criteria to students as a term project in a course entitled "Coastal Engineering." This course was taught by the principal investigator for the first time at VMI in the Spring semester of 1985. Generally, one period a week was designated for the designs and 20 percent of an individual student's grade was based on the design team's written and oral reports.

The design criteria specified were based on an amphibious operation scenario to be conducted on a dynamically changing beach. A beach that could have a bathymetric profile change in a period of hours. This type of beach would be composed mainly of unconsolidated material such as sands and silts. These materials could, under changing environmental conditions such as wind, waves and current, erode or deposit beach material rapidly. The erosion and deposition of this beach material could quickly result in the development of offshore bars that charts or previous investigative information would not designate as being in existence. It should be stressed that this type of data would be extremely important to tactical commanders since it could prevent premature grounding of landing craft and provide support for the use of causeways or the selection of other beach sites. In addition, if the invasion is to be a success, the logistic



support including POL facilities and mobile ports would also require this timely bathymetric information.

The system design criteria stressed the following:

- 1) Determine the water depth from a reference water line to within  $\pm$  one foot over a distance from the first breaking waves to the beach (the surf zone).
- 2) Obtain data rapidly and reliably.
- 3) Withstand and operate in the surf zone environment.
- 4) Operate under all weather conditions.
- 5) Be simple enough to be operated by Naval and Marine Corps forces.
- 6) Be relatively inexpensive, expendable, and reusable.

Three teams of three members each were given the same design criteria. One day a week the class was open to general discussion on the specific design and questions were raised and discussed. Since many of the students were active in Navy and Army ROTC programs, questions about amphibious operations were asked to their ROTC professors and military operating manuals were consulted about critical procedures. Of specific interest was the answer to the following question. At what point, depending upon wave height, would a task force commander consider cancelling an amphibious operation? Generally, if wave heights range from six to eight feet it is ill advised to proceed with an operation because waves of this height travel at the speeds of 6 to 10 kts respectively. Waves of this height and speed would result in unloading difficulties from ships to landing craft. Also, most landing crafts only have a maximum speed of 10 to 12 kts and therefore maneuverability would be difficult. In addition, there is the high possibility of waves outrunning the landing

craft while approaching the beach. This could result in landing craft being carried like a surfboard with total loss of control. The loss of control would result in swamping broaching and possible capsizing of landing craft.

The same wave force that could rake havoc with the landing operation could also be rapidly changing the beach profile. Therefore, prior to the beginning of, or the resumption of the amphibious operation, the beach profile should be checked for hazardous bars.

### Results

Appendix A, entitled The Beach Launched Bathymetric Profiler (BLBP) was prepared by cadets Pauquette, Taylor and Tinsley. This system employs a harpoon gun that is fired from the beach into the surf zone. The harpoon gun has a maximum range of 600 feet. The depth recording sensor has a pressure device and the sensor is retrieved by means of a winch that will provide a digital reading for a distance measurement. The BLBP system is launched perpendicular to the coastline at any desired interval and pressure versus distance profile data is obtained. This data is then converted to depth readings at a specific coordinate point in the area being surveyed. This information is then put into the computer's graphing program and a bathymetric contour chart of the desired area is produced. The BLBP system requires a three-man team for operation and can be produced for \$4,348.00 using state-of-the-arts components.

Appendix B, entitled The HFB-1 Surf Profiler was prepared by

cadets Heishman, Fitzpatrick, and Burch (HFB-1). This system employs a standard Navy line throwing gun having a range of 165 to 300 feet depending up the amount of powder used in the charge. The system can be launched from a ship or the beach, however, the senario proposed in this report assumed a beach launched procedure. The depth recording sensor is a pressure device located in a fiberglass housing. The housing shell is shaped like a horseshoe crab to allow for better stability in the surf zone area. The HFB-1 launching and operating senario is very similar to the BLBP system, however, this system did not use a computer mapping program. The cost of the HFB-1 system is \$3,510.00 and would require only one man for operation. If a more rapid survey is desired, an additional system could be employed and more personnel would be required.

Appendix C, entitled The Rover Data Collecting System was prepared by Cadets Barthol, Hunter and Walus. The Rover system uses a push-pull method of operation in which a vessel as well as a shore team is required. The vessel would moor at a position outside the surf zone. A line would then be launched from the ship and retrieved by the shore team. After the shore team retrieved the line the vessel would lower the sensing unit into the water and the shore team would commence to pull the sensing unit ashore while the ship payed out their retrieval line. Once the sensing unit was on the beach the shore team would move down the beach a desired interval and the ship would take in on its retrieval line while the shore party payed out their retrieval line. This procedure would be repeated until the data was

collected over the desired beach area. The Rover system could have a variable range however the range proposed in this report was 3,000 feet. The sensing unit used for depth was again a pressure device, however, the Rover also incorporated an inclinometer device in order to determine initial touchdown of the sensing unit's subsystem and backup data to support the pressure information on steep sand bars. The cost of the Rover is \$2,020.00 which is mainly for the sensing unit. Most of the other components such as the vessel, vehicle, winches, and lines used in the system are assumed to be provided by either the Navy or Marine Corps forces. A six-man team is required to operate Rover, three on shore and three on the vessel.

#### Discussion

All of the three design systems reported used a pressure device to sense changes in depth. Each system developed a method to convert the cyclical pressure impulse as a result of the wave and effectively determine the depth to the bottom from a reference mean water level. All pressure devices selected were reasonable in cost, rugged, met accuracy specifications and were designed for the marine environment. Only Rover used an additional sensing element called an inclinometer. This device is very sensitive to level changes and would give good indication of sharp changes in bathymetry such as bars or other objects. In addition, an inclinometer reading is a good indicator of the stability of the entire sensing unit.

All systems used a line measuring technique to determine distance of the sensing element from the beach or ship. BLBP and the HFB-1 systems assumed the azimuth of the sensing unit to be in the direction of the line pull. The Rover system did not have to make this assumption since two lines were attached to the sensing unit and therefore positive position control was able to be maintained.

Rover by far had the greatest system range (3,000 feet) and would therefore provide the greatest flexibility. The other two systems, BLBP and HFB-1 had shorter maximum ranges but were simpler and more rapid to operate. In addition, the BLBP and HFB-1 systems required less operating personnel and logistic support.

The cost of all three systems were comparable ranging from \$2,020.00 to \$4,348.00. The variation in costs generally was the result of what each system considered would be provided by Navy or Marine Corps forces. The main costs were associated with the sensing unit sub-system, launch sub-system and the data reduction sub-system. Two of the systems, Rover and BLBP, actually planned to reduce data into a bathymetric relief map using mapping software and computer programs incorporating the IBM Personal Computer.

#### Conclusion and Recommendations

The "Coastal Engineering" course taught at VMI during the second semester 1985 gave the opportunity for students to conduct

a design of a beach profiler for partial fulfillment of the design requirement of that course. Three teams of three individuals each were given the same design criteria and tasked to design a beach profiler system during the semester. The three system designs were generally completed by 1 May 1985 and an oral presentation was given to the ONR sponsor. The written designs were submitted on 10 May 1985. All system designs met the criteria to measure the water depth to within  $\pm$  one foot accuracy. All systems varied in method of deploying the sensing units and in their maximum ranges. Two of the systems propelled the sensing unit into the surf zone where the third system used a push-pull method of deploying the sensing unit in the surf zone. The range of the sensing unit into the surf zone varied from 300 to 3,000 feet. The systems were fairly economical ranging in cost from \$2,020.00 to \$4,348.00 and projected scenarios for employment of the beach profiler systems resulted in requiring from one to six people for operation.

It is recommended that a prototype be developed of the sensing units sub-system and that the methods of employment (propelled and push-pull) be tested in order to determine the accuracy and ease of operation of these systems under actual surf zone conditions. This development would be Phase II of this existing proposal between ONR and VMI. The Design of a Beach Profiler (Phase II) is attached to this final report.

APPENDIX A  
The Beach Launched  
Bathymetric Profiler  
(BLBP)

BEACH LAUNCHED BATHYMETRIC PROFILER

CE 455-1  
Design Project  
Due: Monday 6 May  
Group 3



Group Design Project

BEACH LAUNCHED BATHYMETRIC PROFILER

Group 3

Pauquette, PER

Taylor, SS

Tinsley, JC

## ABSTRACT

The group consisting of Cadets Taylor, Tinsley, and Pauquette, were able to successfully design a device for the purpose of bathymetrically profiling the surf zone. The device is called the Beach Launched Bathymetric Profiler (BLBP). The main component of the BLBP is a pressure transducer (current transducer) made by Teledyne Taber, model 2002. The transducer is attached to a harpoon shaft and launched into the surf zone by a harpoon gun. The BLBP is then reeled in and readings are taken at specified intervals. The data is then recorded and relayed back to a shipboard computer which can turn the data into a visual simulation with the help of a prepackaged program called SURF and TOPO. The components of the system will cost \$4348 and are outlined in detail and their operation discussed in the following paper.

We feel the BLBP is the best solution to the problem of surf zone profiling and we strongly recommend that quick and decisive action be taken to implement our design into the Navy/Marine Corps team. With the help of our device, amphibious landings will be greatly enhanced and the risk to equipment and more importantly, lives will be greatly reduced.

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Today's world of major political conflicts and the potential outbreak of war between countries and possibly continents makes way for the need of advanced equipment to aid the United States Armed Forces. This project is directed towards the initial amphibious assault that maybe necessary for our Navy and Marine Corps while they plan an attack on some abroad coastline. The basic objective or need here is to design an instrument that is capable of quickly determining the bathymetric profile of any given coastline anywhere in the world. This device should locate the ideal surf zone where our allied forces can approach, and actually beach all required equipment and manpower necessary to oppose, suppress, and eventually defeat the enemy.

This, as stated, is a broad goal which we want to achieve but there are several conditions or restraints which made this a difficult and challenging project. The more specific criteria are as follows:

- 1) The instrument must be designed to profile accurately to within  $\pm$  one foot.
- 2) It must be quick and reliable.
- 3) It must be heavy duty and durable.
- 4) It must be designed to operate in all weather conditions.
- 5) It must be small and lightweight and must be simple enough to be operated by reconnaissance forces on the beach.
- 6) It should be inexpensive, expendable, and hopefully, reusable.

Generally, we will have predetermined knowledge about our surf zone location. We will already know whether a stationary solid formation exists such as a coral reef or a solid rock shoreline. This type of information would eliminate the location as a possible landing site as a sandy bottom surf zone is the preferred beach for landings. It would also be useful to correlate the beach site to navigational charts so that an exact point can be located.

This instrument would not be required to operate under seas any larger than six to ten feet as this condition would be a no-go for an amphibious landing. It is apparent that we may encounter a very dynamic zone which could appear almost tranquil from the surface. Environmental factors will always be present and therefore we must design to withstand wind, surges, tides, currents and all types of waves.

Three alternatives were originally considered to fulfill the requirements of our design criteria from which we chose this particular system. First, a sonar device was considered as it would ideally provide all the necessary data but sonar was found to be inappropriate. Firstly, sonar was found to be nonfunctionable in a noisy sandy surf zone and was also extremely expensive to be classified expendable. Secondly, we considered a pressure sensor tape device that would give depth readings along the entire length of the tape. We immediately eliminated this system as the launching,

transmitting, and receiving devices would not be simple and easy to use. Finally, we chose a pressure transducer as the basis for our project as it fit all the requirements as previously stated. Our overall project is composed of a launching system, a pressure transducer, an ammeter, and a retrieval system. Along with this, our project includes computer programs that will graph out a detailed contour map of the location in question.

### Technical Outline

The Beach Launched Bathymetric Profiler (BLBP) is an integrated system consisting of components divided into three main categories.

#### Launching system

Harpoon gun and stand

#### Recording System

Pressure transducer

Fluke 77 meter (ammeter)

24 volt battery

#### Retreival System

Coiler

Digital line reader

Cable

Each component is outlined, briefly, in the following pages. The information is given in a condensed format and is basically self-explanatory. A detailed report on the operation of the entire system follows the description of each component.

# DELIVERY SYSTEM

- Harpoon Gun

- 1) Barrell Length - 18in

- 2) Cost - \$995.00

- Stand for Gun

- 1) Height - 36in

- 2) Cost - \$200.00

- Shaft (Harpoon)

- 1) Cost - \$12.00

- 2) 8-gauge Brass Shell (Reusable) - \$7.00

- 3) Wads - \$15.00

\$995.00

200.00

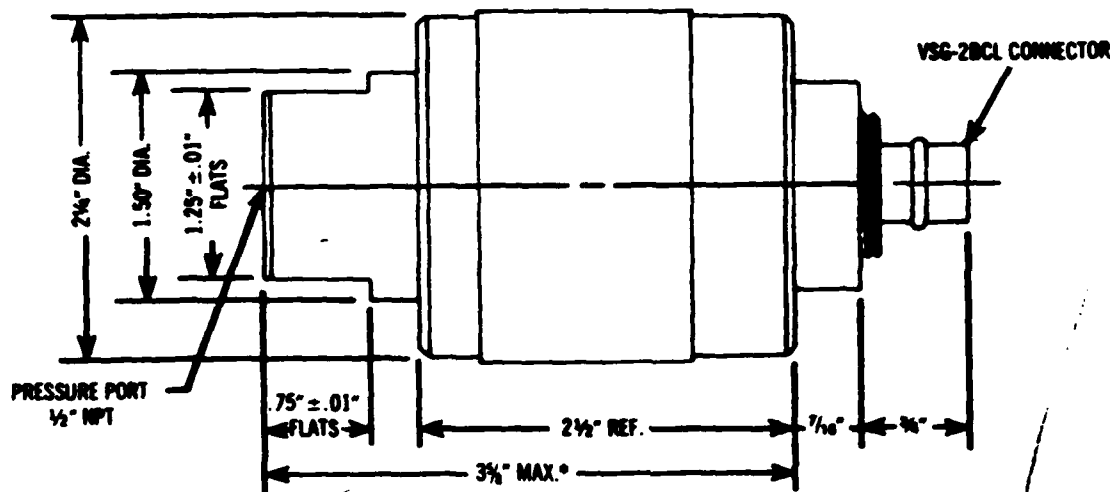
12.00

7.00

+ 15.00

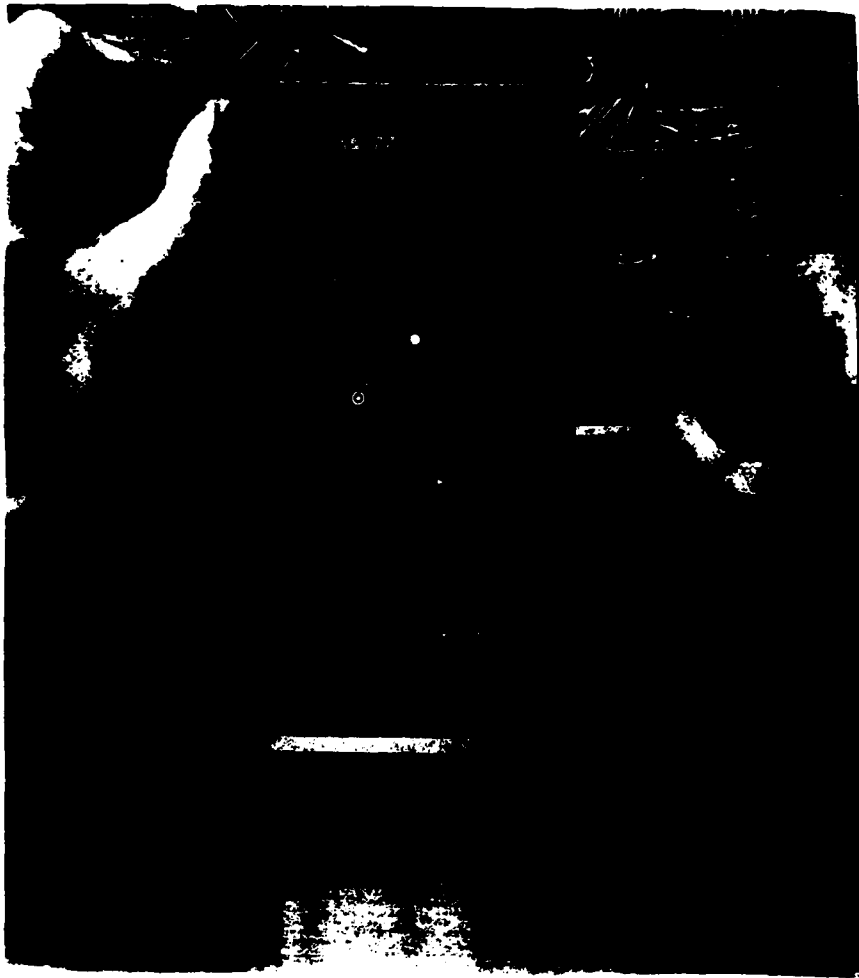
Total - \$1229.00

# Model 2002

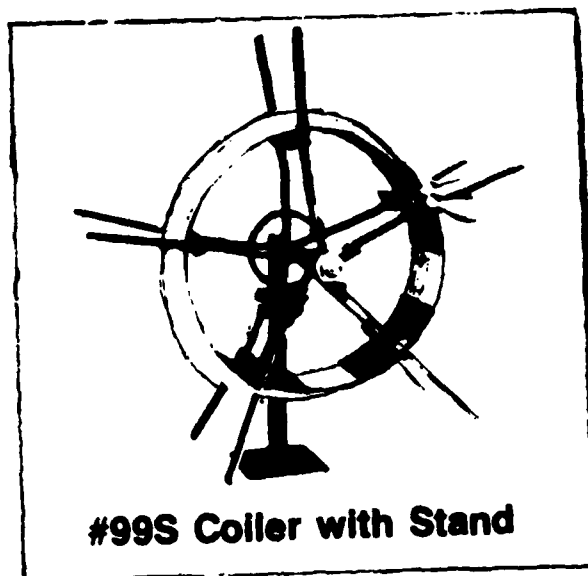


- Weight = 35 ounces
- 100G's applied for 11 milliseconds will not change performance characteristics
- Measures 0-100psi
- Teledyne Taber will pack it (with Silicon) for \$40 extra.
- Cost for Model 2002 ; 600ft of Electrical Connector, and packing is \$1,692.00





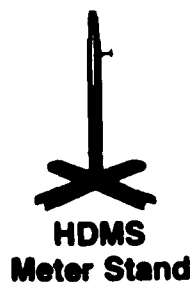
- "Touch Hold" Function
- 0.3% Basic DC Accuracy
- Hand Held
- Audible Beep Given When Valid Reading
- 2000+ Hour Battery Life
- Reads Milliamps



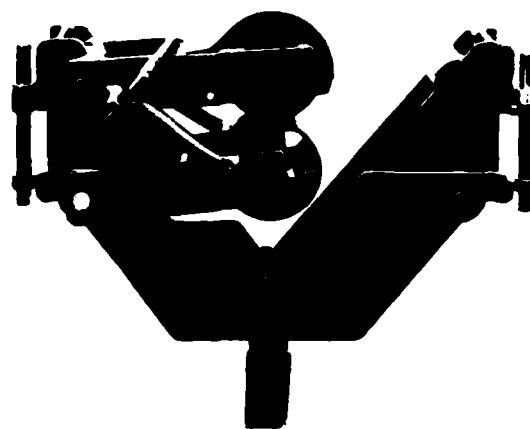
**#99S Coller with Stand**

- **COLLAPSIBLE COILER AND STAND #99S:** (capacity 3½" x 12" x 21") This Collapsible Reel forms a round coil of up to 500' of 10-2 NMC cable, and features rugged construction as well as a brake control to prevent coasting.

\$202.00  
21.0 lbs.



\$139.00



**Shown  
ROM 1700 With Optional  
Side Loading Features**

Side loading option allows you to measure material that has an end, connector, or splice in it that will not pass through a meter.

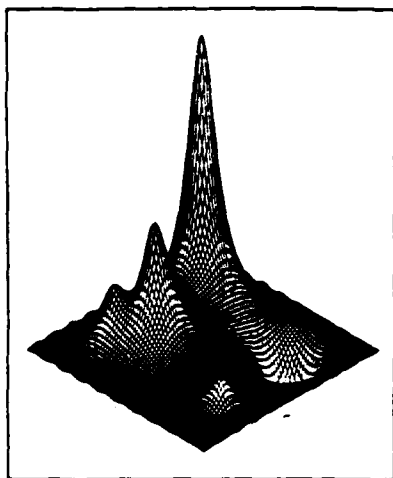
\$783.00

### OPTIONS

- Predetermined Counter
- Digital Read-Out
- Measuring Wheel Brakes
- Remote Read-Out
- Metric Counter

# SURF

**SURF** enables you to interactively create three-dimensional surface plots on most dot-matrix printers.



This is a 3-D surface plot created by **SURF**. The entire plot was created from only five data points.

## With SURF you can . . .

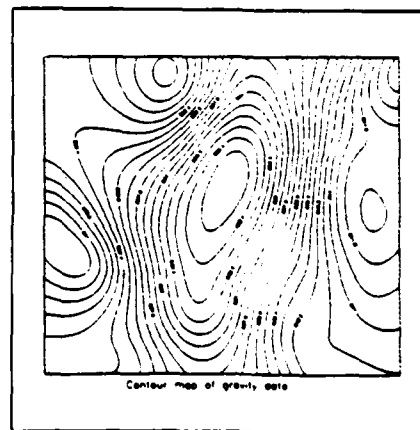
- ☐ generate 3-D surface plots with or without hidden line removal, rotated to any angle.
- ☐ view data and mathematical equations in three dimensions.
- ☐ change the plot size and add a title.
- ☐ choose vertical lines only, horizontal lines only, or both.
- ☐ modify the density of the mesh lines.
- ☐ plot the top of the surface, the bottom, or both.
- ☐ visualize unseen surfaces, such as mineral deposits.

# TOPO

With **TOPO** it's fast and easy to make contour maps. All input is interactive.

## With TOPO you can . . .

- ☐ generate a contour map with in-line contour labels.
- ☐ specify the map size and place a title on the map.
- ☐ view three-dimensional data in two dimensions.
- ☐ change the contour interval size.
- ☐ specify a subset of the data to contour.
- ☐ create a contour map from the same data used by **SURF**.



This is an example contour map created by **TOPO**.

### Operation

The Beach Launched Bathymetric Profiler is a relatively simple system which only requires a three man team to operate. The major components are mounted in the back of a Marine Corps jeep. That is, the harpoon gun and stand, the power source (a 24 volt battery), the ammeter (Fluke 77), and the coiler and digital line reader are all mounted in the jeep. The breakdown of the three man team reveals that each man has a particular duty to perform during the operation of the BLBP. The No. 1 man is the driver/ phone operator, his primary duty is to drive the jeep into position. The No. 2 man (launcher/loader/reeler) then adjusts the charge of the gun and launches the harpoon/pressure transducer into the surf zone. The No. 2 man is also responsible for reeling the pressure transducer in and reading the digital line reader. At specified intervals, five to ten yards being optimum, he will call out the distance of the transducer. The No. 3 man will then activate the ammeter and record both the distance and the current in a table similar to the one below.

<u>Distance (yards)</u>	<u>Current (milliamps)</u>
175	17
170	17
165	16.76
160	14.53
155	14.87
. . .	. . .

When the transducer is retrieved the No. 2 man will then load the harpoon shaft, with the transducer attached to the front, and the No. 1 man will drive a specified interval, 100 yards maximum, to the next station. The entire process will then be repeated again. While the transducer is being retrieved this time, the No.1 man (driver/ phone operator) will phone in the preceding station's measurements. On board ship (anything from an LST to an LCC) the data will be typed into a computer. Utilizing a program we designed and the pre-packaged SURF and TOPO programs the milliamps will be converted to a pressure (feet of seawater) and then graphically displayed in either three dimensions or as a topographical map.

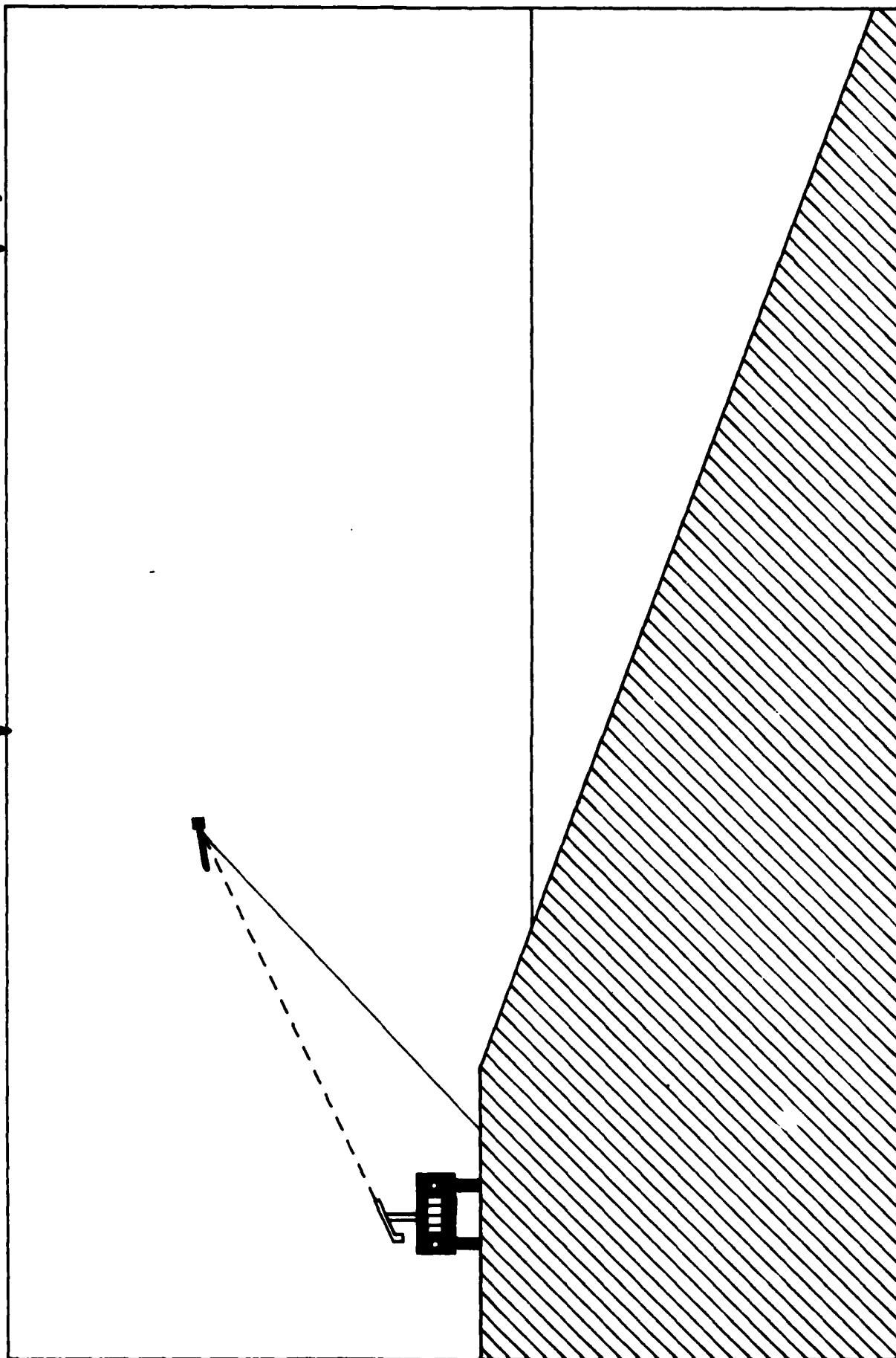
A breakdown of the system shows how the components are utilized to give the desired results:

- 1) The pressure transducer powered by the 24 volt battery will take continual readings.
- 2) A wire carries the current from the transducer to an ammeter (Fluke 77) located in the jeep.
- 3) The milliamps and the distance are recorded at specified intervals.
- 4) Aboard ship, the milliamps are converted to feet of water using a computer.
- 5) The data is then interpreted by computer graphing procedures.

PRE LAUNCH (Set up for delivery)

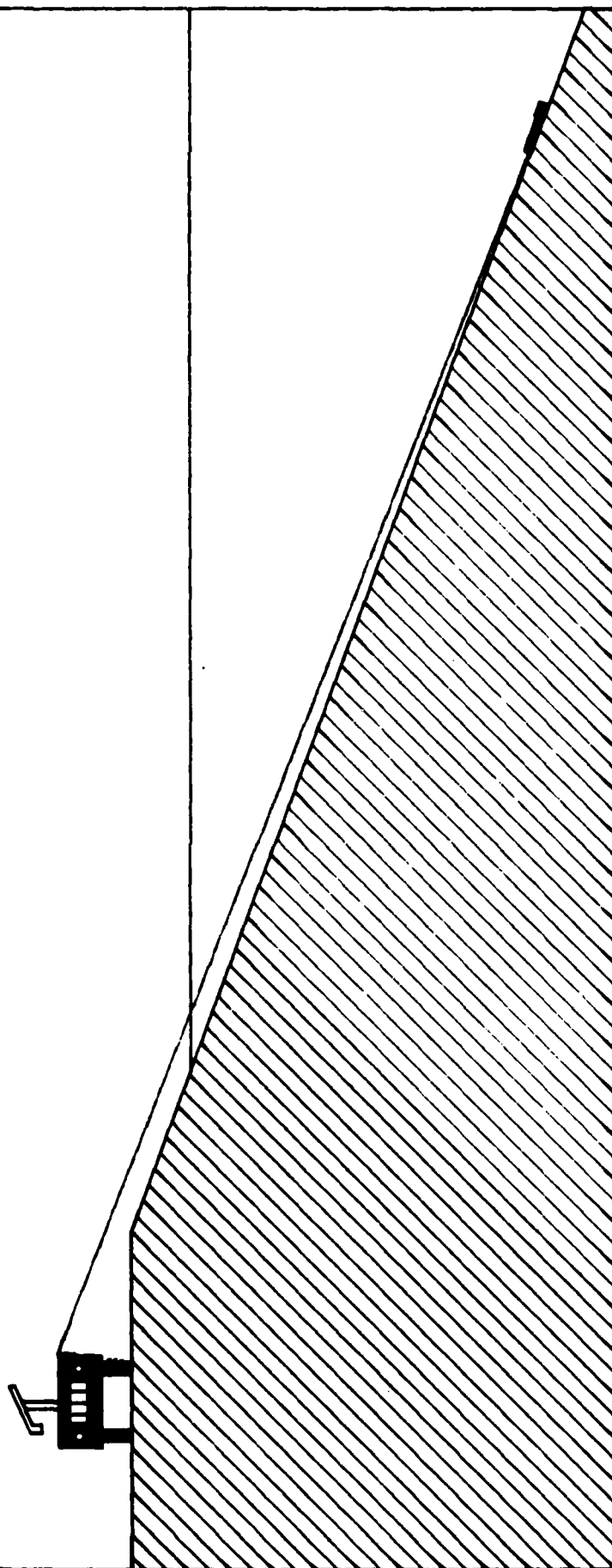


LAUNCH (Harpoon launched w/ wire played out)





# RETRIEVAL (DATA IS TAKEN)



## Results and Conclusions

Using the criteria previously described, we feel that the BLBP has met and exceeded the desired goal. The BLBP should become an integral system in the Navy/Marine Corps team due to its accuracy, simplicity, usefulness, and cost conscious design. Using the BLBP, an amphibious landing can be carried out with both greater expediency and a reduced risk to life and equipment. Please note the simplicity and reliability of the BLBP. Should an entanglement or snag occur, the harpoon shaft/pressure transducer can be jettisoned by applying 40 lb.s of tension to the cable. At that point the connector will break and the wire can be retrieved. In a matter of seconds a new shaft can be attached and the device is ready for action. Our group has ensured that the system will last for quite some time also. Many of our components are designed to exceed military specifications. The pressure transducer circuitry is silicon packed so as to hold up to more shock and abuse. The Fluke 77 can be packaged in a plastic yellow case which is waterproof.

In conclusion, we feel our design is the best for the previously mentioned reasons. The BLBP should be incorporated into amphibious operations as soon as possible! Its use and effectiveness would prove invaluable to the Navy/Marine Corps team.

### Problem Areas

Although the BLBP is an innovative and reliable system, like all new designs, it is not without a few problems. In reaching our final design, we ascertained the following problems:

- 1) The pressure transducer must be attached to the harpoon shaft so as to achieve balance and good bonding. By attaching the transducer to the front of the shaft we hope to alleviate any problems of flight. However, we have not found a reliable way to bond the shaft and the transducer. The transducer casing is stainless steel, which requires certain welding practices and often yields an unreliable bond.
- 2) The connector between the pressure transducer and the cable is only able to withstand 40 lbs. of tension. We hope to alleviate any problems caused by the uncoiling of the cable during the launch phase by playing out the cable on the ground prior to launching. When fired the harpoon shaft will be able to fly up to 600 feet without any forces acting counterproductively.
- 3) As of the time this report was written, a computer program to convert milliamps to feet of water was not completed. The programming is relatively simple and is outlined as the following:

The pressure transducer converts pressure to a current between 4 and 20 milliamps. The scale of the transducer is 0-100 psi.

Therefore,

$$(X-4, \text{ mA}) \left( \frac{100 \text{ psi}}{16 \text{ mA}} \right) = Y, \text{ psi}$$

specific      range of  
reading      operation

$$Y \text{ psi} \left( \frac{33.91 \text{ ft of water}}{14.7 \text{ psi}} \right) = Z, \text{ ft. of water}$$

conversion factor

#### Acknowledgements

- Teledyne Taber whose information was invaluable in the development of this system.
- Cadet Craig R. Lamb who advised us on transducer operation and the Fluke meter.

APPENDIX B  
HFB-1 Surf Profiler

HFB-1

SURF PROFILER

GROUP NO. 1

STUART N. HEISHMAN

THOMAS J. FITZPATRICK

PAUL W. BURCH

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CREDITS.....	PG. 14.

## ABSTRACT

There exists a problem such that the solution required is a device that will quickly and effectively determine the bathymetric relief of surf zone anywhere in the world. There are certain design assumptions that must be met in order to make the unit as simple to operate and maintain as possible. The various components of the device are the shell, which is designed to look like a horseshoe crab; a pressure transducer which will indicate by pressure readings the depth of the water at a specified point; a transmission line which will act as a retrieving system as well as an encasement for four wires required to operate the pressure transducer: two which will supply power and two that will relay the pressure readings from pressure volt pulses from the transducer, the water depth; and finally a power winch which will retrieve the system by reeling in the cable. The merits of the system proved and the assumptions are also confirmed as reasonable. Conclusions can be drawn from the reliability of the equipment, guaranteed by the manufacturer, which indicate that the unit will efficiently and effectively solve the design problem.



## INTRODUCTION

Engineering design is an iterative, decision making activity to produce the plans by which resources are converted, preferably optimally, into systems or devices to meet human needs. The engineering design process however is initiated when there is the need for such plans and products. It is up to the engineer to translate this need into a statement of goals and objectives. This translation includes defining the need in terms of identifying resources, boundary conditions or constraints and the presentation of criteria for judging the results. These steps are commonly known as the feasibility of the project.

Throughout the world, sadly enough, there are disputes which often entail armed conflict between countries. To this end, effective planning and execution of fighting tactics is essential to determine positive outcomes of these disputes, for either side. In planning an assault one must know the strength of the enemy, the technique and fighting procedure of the same, and one must know the environment in which the assault will take place. The latter is of great concern, and it is that problem with which this paper is meant to resolve. The part of the environment and in particular the profile of a beach. The need, therefore, is to design and produce a device that will quickly and accurately measure the bathymetric relief of any given beach under any given conditions. The device must be suited to the ocean environment and thus must be capable of withstanding the wave forces, the

pressure of the water, the force of impact when delivering the device to the designated section of the beach, and the device must be able to withstand the threat of salt water. The device must be simple but competent, durable yet inexpensive, reusable but if need be expendible.

Obviously there is no one machine or device capable of functioning under any conditions on any beach. To be realistic it is our responsibility to develop the device that will function under as many circumstances as possible. With this in mind it now becomes important to establish a few design criteria or basic design assumptions. The first is that the device will be collecting data on a smooth impermeable beach. Of course there may be obstructions, either man-made or natural that may impede the efficiency of the device, but our assumption is one that must be used in order to derive a general design. The second major design assumption is that the device will collect data based on the mean water level. Naturally there will be wave troughs and crests and differences in tides that may alter data from day to day, but by using modern day state-of-the-art technology much of this fluctuation can be reduced so that our assumption is valid to a reasonable degree.

Boundary conditions and restraints that must be met or overcome are numerous. The device, or at least the components must be entirely waterproof. The device will be working exclusively in the ocean where salt water could ruin something in an incredibly short period of time. The device must be small and

light for delivery of the system will become even a greater task if the device is not. The device must be inexpensive for if it were to be mass produced it would then become too costly. Other restraints include accuracy, and durability in terms of life expectancy.

### ALTERNATIVES

The design that we feel best fulfills our expectations is the HBF-1 surf zone profiler. However we did not stumble upon the final design without first considering competitive alternatives. The first of which was the use of sonar. The process of transporting a sonar device to the desired location on the beach was considered to be an overwhelming problem. It was also determined that in the manner in which we intended to use it, the sonar device would not withstand the environmental conditions that would be placed upon it. The idea of using sonar was thus abandoned. We proceeded to investigate the use of a depth finder device. In-depth research indicated that to use this device it would have to be placed directly over the point where the depth was to be found. This proved ineffective in many ways. In particular with the device needing to be held over the special area, it would have to be fastened to a boat of some kind or held by a diver. This proved inefficient because neither the boat nor the diver could withstand the turbulent wave forces of the surf zone while remaining stationary long enough to make

readings. This idea was also abandoned. Lastly we came upon a device that was very similar in idea to the HFB-1. The component parts were relatively the same however the means of transporting the device to the designated location proved to be its downfall. The means of transporting the device to the surf zone was by using an underwater scooter. However, once in surf zone the scooter would be impossible to control due to the turbulent wave forces. Thus through slight modification our group came up with the HFB-1.

#### COMPONENTS & OPERATION

A great deal of thought went into the components and parts of the HFB-1 surf zone profiler. Finding the proper parts and instruments was difficult. Due to the ocean environment, dynamic forces, salt and sand, currents, etc. stringent specifications had to be met in order to develop a satisfactory product. However, our objective and goal was not to have a satisfactory product but rather a superior product.

Fortunately, our specifications for dealing with the surf zone and ocean environment were met without sacrificing our high standards.

An actual model was not made nor were there any experiments conducted. However, effects due to buoyancy, currents, tides, and dynamic forces were seriously studied and analyzed. From these considerations. We feel that our product is realistic for constructions and operation.

In general, the instrument is a simple device which can be operated from a midshipman to an Admiral. This was a prime consideration. The instrument is a durable device whether it is treated like a piece of China or a piece of trash. Without emphasizing the instruments durability, the product would be ineffective for its intended use as a military device.

The HFB-1 is composed of six basic parts or components. These parts include: the outer shell, pressure transducer, cable, digital readout, winch and a line throwing gun.

Several alternatives were considered for the shell. Aluminum or other types of metal were first considered. This very quickly became a problem for three reasons. First, the object would have too much unnecessary weight when being fired. Second, the metal and fabrication would be very costly. Third, the aluminum or metal was more susceptible to corroding in the ocean environment (Aluminum might not corrode however, other metals would not necessarily hold up in the saline environment).

Plastic was another possible solution; however, this was quickly eliminated since contact on impact or obstructions in the water could possibly crack the shell. Finally, fiberglass turned out to be the best solution. The additional strength due to the fiberglass made it more durable than regular plastic. More importantly the fiberglass was lightweight enough to be fired or projected into the water. Air drag forces were reduced. For the price and the strength to weight ratio, fiberglass was by far the best solution. Fiberglass is easy to work with in molding shapes

therefore, the desired design shape of a miniature horseshoe crab was achieved.

The pressure transducer was the vital part of the entire design project. After serious consideration, the decision was made to use the model 2000 oceanographic pressure transducer from Teledyne Taber. This completely submersible instrument can measure from 0 to 100 psi and or 0 to 10000 psi. For our purposes the 0-100 psi is sufficient. The transducer is operatable in -55 degrees Centigrade to 100 degree Centigrade temperatures. The proof pressure has a factor of safety of 3 times its pressure range. In addition, the transducer can withstand 100 G's for 11 milliseconds without causing damage. The transducer, which has the greatest percentage of the total instrument weight, weighs only 45 ounces. The output is from zero to five volts and only requires 24 volts to operate on.

Other models of pressure transducers, as well as other brands, did not have the qualities and characteristics to function in the maritime environment.

The cable used on the design is from the Bratner Corporation. The cable is specially designed for ocean use. In addition, the cable is designed to fit the pressure transducer and the digital read out device. The cable contains four wires. Two of the wires are used as power supply lines sent from the digital readout device to the pressure transducer. The other two wires are used for the voltage transmission in which volt impulses are sent back and forth from the pressure transducer to

the digital read out. The four wires are insulated by the cable in order to protect any corrosion or damage that could effect the proper operation of the HFB-1.

The digital readout was selected from the Lincoln Instrument Company in Pasadena, California. Part of the reasoning in the selection was based on the fact that Lincoln Instruments had done prior work with Teledyne Taber pressure transducers. The dimensions of the digital readout are 3.88" x 4.50 x 1.67. The digital display is approximately 1/2 inch. The device is the Sirius Model 3-A. It is designed to receive voltage readings of 0 to 5 volts (the pressure transducer sends out from 0 to 5 volts). The read out contains a 24 volt supply inside of it. This supplies the power to the transducer via the cable. As one can tell the read out. The digital readout on it is calibrated so that it will convert the voltage impulse into feet of water (depth).

A regular voltmeter was considered. However, since you have the fluctuating values due to the swell of the waves (wave height, depth value at the trough, and depth value at the crest) a simple voltmeter would be impossible to read. Therefore a capacitor would have to be placed in front of or before the voltmeter. The capacitor eliminates the fluctuating values and gives you the water depth value in relation to mean water level.

All in all the solution of a capacitor and a voltmeter is ineffective from two stand points. First, it is more costly to have this type of setup (compared to out digital read out).

Second, the capacitor-voltmeter takes up more space than the compact digital readout. Therefore, based on cost, practicality and space requirements, the digital readout far outweighs the capacitor-voltmeter combination. Besides, the voltmeter did not necessarily contain the power source for itself and the pressure transducer. It also should be noted that the digital read out is capable of having computers connected to it to analyze data.

The digital read out is attached to the winch. The winch is a "power winch" from the Golo company. By the sound of its name, it is a self powered winch. The cable is connected to it and reeled in by the power winch. The cable is marked in increments of feet. As the HFB-1 is reeled in, the distance from the reeling point to the point where the pressure transducer is reading from can be read. This is crucial information in determining where the depth location is being taken. The convenient feature about the winch is the fact that the data collector does not have to manually reel it in. Rather he can just take down the data from distance on the cable and the depth from the digital read out.

The last part of the HFB-1 is the line throwing gun which launches the HFB-1. This device will launch the instrument several hundred feet into the surfzone. The line being thrown is the cable. The instrument is attached to the cable via an eyelet hook (which is connected or attached to the fiberglass shell). The instrument is relatively light and is aerodynamic in design, reducing any possible drag. The line throwing gun would be one



of the U.S. Navy's, with maybe a few alternations. Looking at all of the different components, the line throwing device appears to be the only weak link in the system. However, research can be done and alterations could be made on the line throwing guns in order to be more suitable for our purposes. In general, the instruments and devices selected should interact and function well together.

The operation of the device is relatively simple, for this is one of the key considerations that we took into account in designing the instrument. For the most part one man (or woman) could operate the device. First of all the HFB-1 can be fired from the beach into the water or from a boat toward the beach. Either way will work.

The first step is to load the throwing gun, making sure that the cable is coiled up in a fashion so it will easily unravel. Also make sure the free end is actually free and not attached to the winch. The second step, upon completion of launching the instrument in the surf zone, is to connect the cable to the winch and to the digital read out. At this point power will be supplied to the pressure transducer. The third step is to start reeling the device in, recording the data every certain amount of feet. The transducer is capable of measuring to within one tenth of a foot. Therefore, results are accurate. After the data has been collected, the operator would repeat the procedure but at a certain distance away from the last point (obviously the data readings should be spaced somewhere between 10-20' apart in

intervals, depending on how accurate you wanted Bathymetric relief).

The HFB-1 is a modern piece of equipment and could be a break thru in technology in the field of mapping and finding bathymetric relief. Particularly since the zone in question is the surf zone which is extremely turbulent. Recommended improvements for the HFB-1 should be concentrated in the area of the launching device. Considering all of the problems and obstacles that had to be examined during the design, the launching or firing system was the most difficult problem to defeat. Although, this problem is not impossible (after all we did come up with a solution). Research and testing should be investigated for firing devices.

During our presentation several problems, which we had not really considered arose. The biggest problem was locating the data information in terms of the actual location on the ground. Our initial thought was to take an aerial photograph prior to the data collection. Then a point could be located on the beach and that point would represent the starting point. However, after giving the problem some thought, the easiest and most effective method would be to shoot an azimuth to a ship or another known point and use simple modified resection to locate our starting points on the beach. This would be a quick and relative accurate method. The only additional equipment needed would be a compass.

Modeling the device was difficult with the resources and funds available. We more or less concerned ourselves, through

drawings, with the buoyancy forces and dynamic forces applied on the horseshoe crab shape object. The buoyancy problem was easily solved. Slits were made in the back of the HFB-1. This would prevent the device from being easily swayed by currents. It gave the HFB-1 more weight while in the water yet had no extra weight when being fired. (Note-The transducer is waterproof and can be exposed to the water. Same with the cable).

At this stage we strongly recommend that a full size (7"x5"x4") HFB-1 model be constructed and tested. This would provide the most accurate test for determining the workability of the device. However, we are confident that this device, the HFB-1, will function and will be successful.

#### CONCLUSION

The HFB-1 Surf Profiler is a very valuable device for finding the bathymetric profile of the surf zone for various reasons. First, the HFB-1 is cost effective. The total price of our product is \$3510. This is a small sum to pay for the valuable information which could determine the success of an amphibious operation during war-time. Second, our unit is very practical. The HFB-1 can be operated totally by one man. One man can fire the device with the line gun, reel it back in with the power winch, and take the readings from the voltmeter. Our device does not require advanced technical knowledge for operation. Any man who is capable of pushing buttons and reading numbers can operate the HFB-1. The HFB-1 also saves time. To

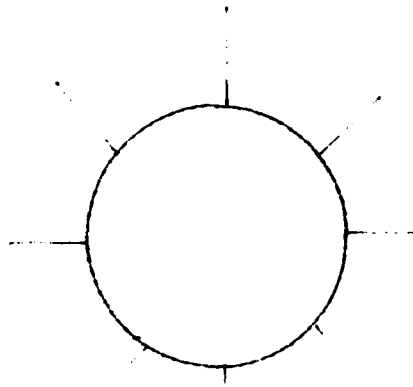
obtain the profile of a large area in the surf zone, a number of men, each armed with their own HFB-1, can spread out at specified intervals along the beach and operate the devices at the same time. This would obtain the surf zone profile in a short period of time. The third and final reason our device is superior is its durability. All of our product's components are quality made for use in the ocean environment. The salt water and rough waves have no affect on the HFB-1's performance.

The HFB-1 Surf Profiler is a very simple device but it gets the job done better then any of its kind. Its implicity and accuracy make it very valuable for military purposes. The cost, practicality, and durability make the HFB-1 the best surf zone profiler for the Navy to consider for use in amphibious landings.

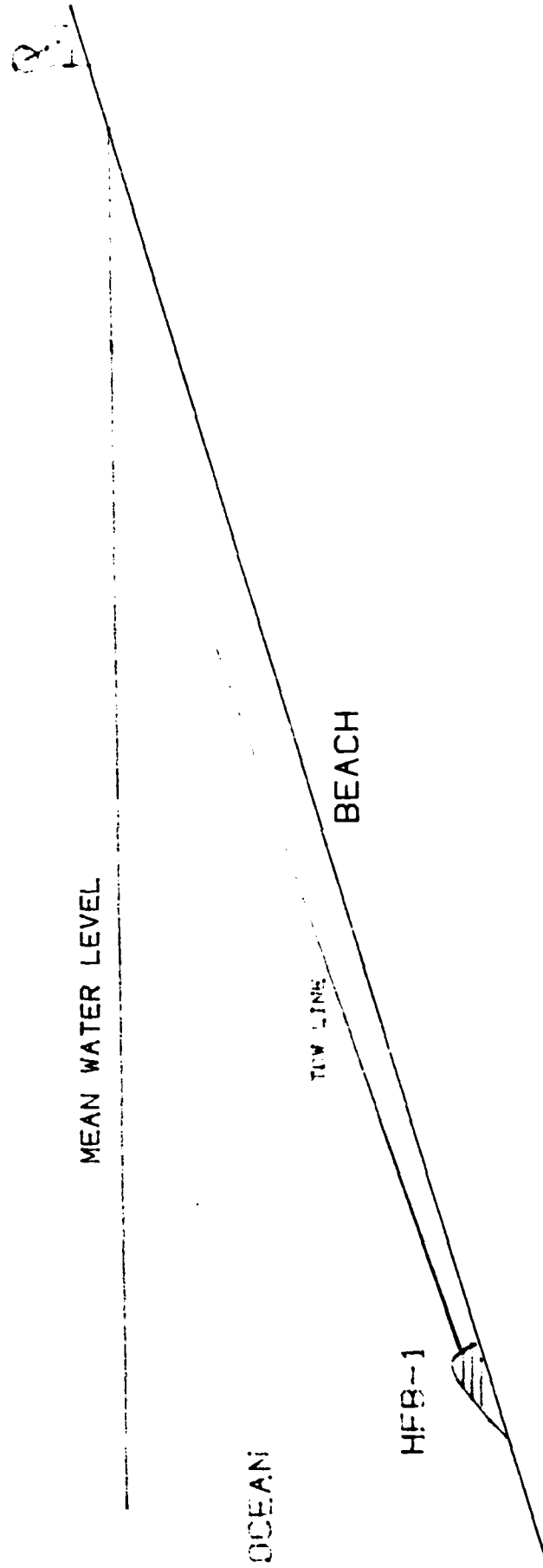
#### PROBLEMS

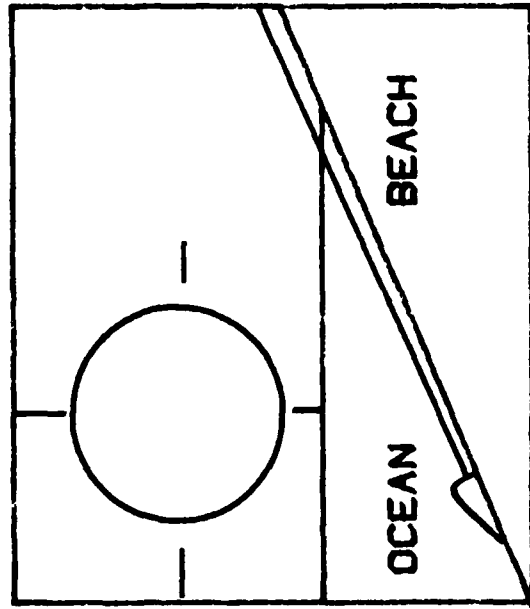
One problem which can be foreseen with the HFB-1 is its shape. There is concern that the device will turn upside down as it lands or that the unit will dig its way into the sea floor. This problem can only be dealt with by doing more research and actually testing a trial unit. Another problem is how to take our profile readings and present them in a form which shows where the readings are taken from. This will create a product which the vessels can use for amphibious landings. These problems, through research and trial runs, can be solved to make our device more successful.

ASSUME TIDING



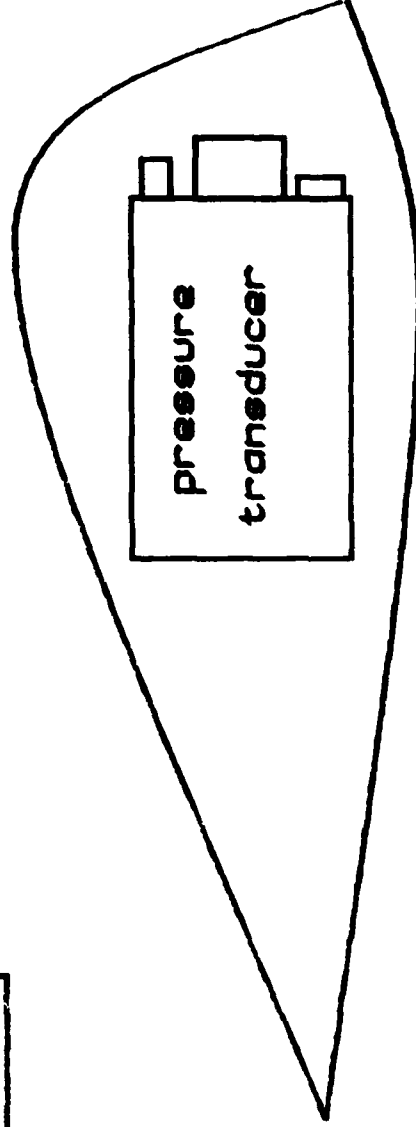
1. smooth, impermeable beach surface
2. pressure based on mean water level
3. HFB-1 can be launched from beach





## ASSUMPTIONS

1. smooth impermeable beach
2. pressure based on mean water level



# COMPONENTS/PRICE

FIBERGLASS SHELL	\$500.00
PRESSURE TRANSDUCER	1240.00
DIGITAL READOUT WITH POWER	345.00
CABLE	270.00
WINCH	1155.00
	-
TOTAL	\$3,510.00

## CREDITS

We would like to express our thanks to the following people for their comments and help for the design of our project:

Henry Stry, Teledyne Tabek

COL. Lee Nichols, VA. Militia, EE Dept., VMI

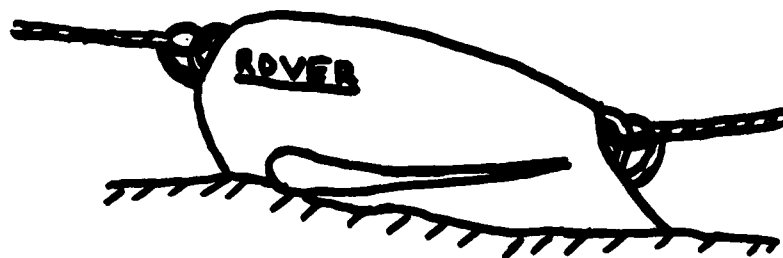
CMDR. Ronald Erchul, USN, CE Dept., VMI

CAPT. Owen Kirkley, USN(Ret.), CE Dept., VMI

\*Help Received: Cadet Whitty, J.T. made a few small grammatical corrections while typing the paper. He also adjusted the numbers on the Table of Contents.



ROVER  
DATA COLLECTING  
SYSTEMS LIMITED



The Rover Bathymetric Measuring Device

CE 455-1  
Coastal Engineering  
Commander Erchul  
Group #2  
Group Members:  
Walus, K.R. (Team Leader)  
Barthol, D.  
Hunter, D.S.

## ABSTRACT

This design report gives the most feasible method of finding the "bathymetric relief perpendicular to the shoreline"(1) in any weather and on any beach. Numerous methods and their results of operation are compared and contrasted and the most feasible method is determined. At the conclusion of this report the reader will understand how the bathymetric relief finder's components operate and how the entire system is deployed.

## PROBLEM DEFINITION

At the present time Cadets Barthol, D.L., Walus, K.R., and Hunter, D.S. are enrolled in CE 455, which is Ocean and Coastal Engineering. The group has been given the problem to design a system which will give information about an area of the beach known as the breaker or surf zone. (2) The main information that must be collected includes the mean water depth, slope of the bottom, and length of the area where the data is collected. With this data, the Navy Marine Corps team will be able to determine if an amphibious landing can take place. Having this important data will prevent the dangerous and premature beaching of landing craft before they actually reach the beach. This data must be very accurate; water depth should be within plus or minus one foot, and it must be obtained very quickly. The new system which is designed should replace a part of the Navy Seal's job. The new system will keep these men out of the water and therefore prevent the loss of lives in the unpredictable surf zone during and after an amphibious landing into a hostile area.

There were numerous constraints that were considered for our problem. Our system should be designed to operate in waves up to six feet and cover an area of approximately 3000 feet. (3) The system should be submersible and constructed with a material that will withstand salt water. It should also be able to withstand a large impact and be more or less expendable.

## Alternative Solutions

### Means of Projection

Projecting the rover onto the beach is a very important consideration since the distance that must be covered is approximately 3,000ft. the system must have low trajectory to reduce excess cable while obtaining the required range.<sup>4</sup> It should also be unrestricted by shallow obstructions such as sandbars.

Our first alternative is the 60mm M224 lightweight mortar. Advantages of the mortar are its weight and range. the conventional model weighs 46.5lbs and the handheld model weighs only 18lbs which allows easy mobility. the range of the mortar is approximately 11,500ft which is excellent considering a surf zone of 3,000ft. The disadvantages, however, are its high trajectory, causing an excess of cable, and difficulty in attaching a cable to the mortar.

Our second alternative is the MK87 MOD1 Line Throwing Rifle Adapter. The advantage of the Line Thrower is its weight, which is approximately 7.8lbs. Since the Line Thrower requires high trajectory for maximum range it is unsuitable. Like the mortar, because of excess cable. Using 0 degree trajectory the Line Thrower has a maximum range of only 135-165ft depending upon whether an M14 or M16 rifle is used.

Our third alternative is a torpedo. The only advantage of a torpedo is its suitability for a clandestine operation. The

disadvantage, which makes it very undesirable, is its inability to reach the beach in the event of shallow obstructions.

Our fourth alternative is sea animals, such as porpoise or seals. The only advantage to sea animals is, like the torpedo, its use in a clandestine operation. Disadvantages of using sea animals are numerous. One disadvantage is the inability to stop at desired points to obtain data. Another disadvantage is that sonar would be required to determine distances which would give false readings because of disturbances in the surf zone. Like the torpedo, obtaining data up to the beach would be impossible in the case of shallow obstructions. Maintaining the animals onboard ship and training them would also pose serious problems.

#### Method of Operation

The method of operation must be quick while also obtaining accurate readings. It should also require as few personnel to operate in order to reduce the chance of casualties.

Our first alternative is to place pressure transducers equidistant along a submerged cable. This system is a quick means of obtaining data. However, assuming 30 transducers per cable at a cost of \$1240 each would result in a total cost of \$37,200 for each cable which is too expensive. Also, each transducer would require 2 wires in order to relay the

information back to the base element. Finally, the chance of the Rover snagging on the ocean floor is great.

Our second alternative is to project the Rover onto the beach and reel it onto the ship. This system would not require beach personnel to prepare the system for operation thus reducing the chance of casualties. Firing the Rover onto the beach would damage the pressure transducer since it can not withstand the acceleration in firing. This system like the first has a great chance of snagging on the ocean floor.

Our third alternative is to fire a cable onto the beach and reel the Rover from the ship to the beach. Then move the cable and Rover down the beach and reel the Rover from the beach to the ship. The only advantage of this system is it requires only one cable to be fired. The disadvantages are its difficulty in moving the submerged cable and, like the first and second alternatives, snagging on the ocean floor.

### Proposed Solution

Our proposed solution in determining the bathymetric contours of a proposed amphibious landing site is a device which we have called the "ROVER". The Rover is a ocean bottom traveling system. This system has the ability to measure the water pressure, which in turn will provide the mean water depth, the inclination of the ocean bottom and the distance the system travels.

To see how the "Rover" operates we must first step back and take a look at the entire system as a whole. To do this I have broken the system down into its' basic components.

1. Equipment
  - A. Delivering Apparatus
  - B. Rovers' Components
  - C. Data Interpretation System
2. How the System Works
  - A. Delivering Operation
  - B. Data Collection
  - C. How Data is Used
3. Cost Analysis



### Equipment

- A. Delivering Appartus (O=Organic to Military)
  - 1. Naval Patrol Boat (O)
  - 2. M220 Tow Missile System (O)
  - 3. Two Motor Driven Winches (O)
  - 4. 8000 Feet of Electrical Wire (O)
- B. Rovers' Components
  - 1. One Oceanographic Transducer (Teledynetaber)
  - 2. One Inclinator
  - 3. Voltage Power Source (O)
  - 4. Two Analog to Digital Convertors
  - 5. One 8255 Interfacing Chip
  - 6. One Odeometer
  - 7. One Container (Motorcycle Gasoline Tank)
- C. Data Interpretation System
  - 1. Input/Output Port Computer (O)
  - 2. Graphic Plotter (O)
  - 3. Docu Map Program by Morgan-Fairchild, Inc.
  - 4. Program for interpreting and storing data.

## How the System Works

### A. Delivering Apparatus

With the understanding that a zone of influence has already been established by friendly forces on the beach to be landed on. A team of 2 to 3 men will be stationed along the beach with two motor driven winches and a communication radio. Another team will be anchored offshore in the naval patrol boat. The second team is the operational headquarters (HQ) for the project. Here the HQ team will fire an inert round from the TOW weapons system at an angle of 60 degrees upshore from perpendicular to the beach. The TOW is wire guided and has a high accuracy up to 3000 meters. After the shell has been fired, the wire which is still attached to the TOW will be picked up by the beach team. This wire will be connected to one of the motor driven winches located on the beach. The HQ team will detach the wire from the Tow weapons system and attach to the Rover. Once the wire is connected to the Rover the voltage supply and data feedback cable will be connected. Therefore the Rover will be in constant contact with both teams while in operation. Thus providing the opportunity to adjust the position of the Rover from either teams in case of a snag. Once both lines have been secured the HQ team will take a compass reading in the direction the beach team is from the patrol boat. This reading will be stored for future reference when the data plotting is begun. The system is now ready for operation.

## B. Data Collection

With the driving and voltage supply lines connected, the Rover is lowered into the water from the patrol boat. Thus no initial impact is experienced by the system which could damage the internal mechanisms of the device. Once on the ocean bottom the beach team will be instructed to tighten the driving line until the first 100 foot mark on the odometer is reached. Upon reaching the first 100 foot mark the HQ team will begin taking data over a period of time no less than the period of the incoming wave. When data is being taken the Rover is in a stationary position. This will allow the computer to read a varying pressure due to the motion of the incoming wave. Thus a maximum and minimum value can be determined. These values will be averaged and stored by the home program. This average value will give the mean water depth at that point.

After information has been gathered at that point the HQ team will radio to the beach team to pull the Rover into shore. The beach team will pull the Rover until they reach the next 100 foot mark. The distance between data points can be varied depending on the time allotted for the mission and the length of the surfzone to be measured. The distance will be gaged by a standard truck odometer located on each motor driven winch. After the Rover is in its new location the data is once again taken.

This process is continued repeatedly until the Rover has made it to shore. While at shore, the Rover is removed from the line for a temporary adjustment in the beach teams position.

The beach team at this time will move to a new position located down the beach 100 to 200 feet to where the second motor driven winch has been located. To regress for a minute...while the data was being collected in the first line a second inert TOW round was fired from the ship in a direction 30 degree upshore from perpendicular to the beach. This line is attached to the second winch on the beach. A second voltage and data cable is attached to this line from the ship and pulled to shore by the second winch. (Note: the patrol boat will not have to move at all while the Rover is performing its operation.) Once the beach team has set up at the new location the Rover is attached to the second cable and placed in position to perform the next run of data points. The first winch is now moved down the beach to the third position which is located approximately 100-200 feet from the second position. Or perpendicular to the beach. Once the Rover has completed its initial run the data cable is retrieved by the HQ team. The first data cable is then prepared to be drawn out to the third point down the beach. This same process is repeated in the establishing of the fourth and fifth stations. These stations will be an additional 30 degrees downshore from the previous stations. \*Check Figure 1a for example of the project data lines\*

### C. How Data is Used

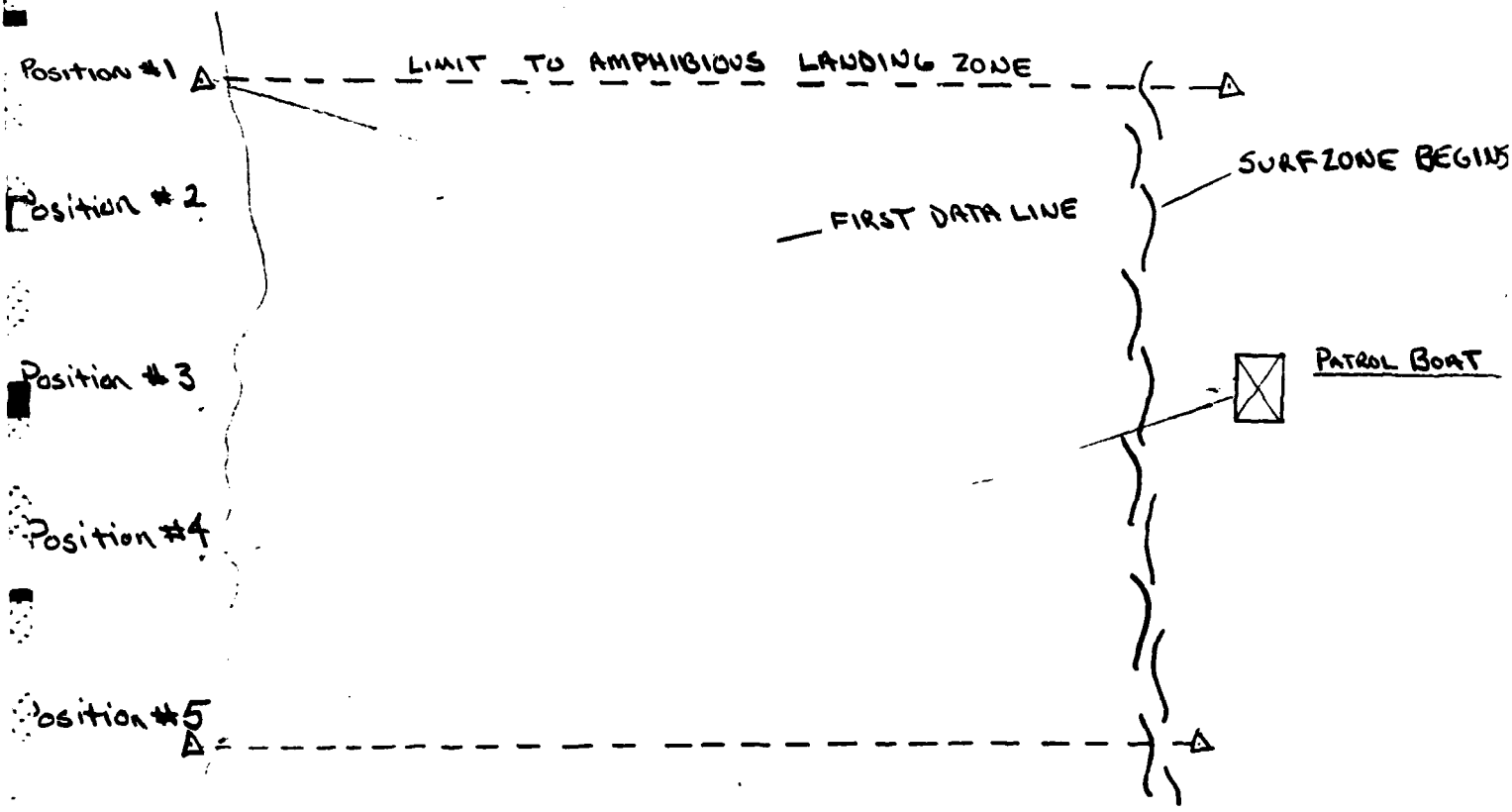
The information system we have designed will take in the data and store it until plotting is desired. The main program will be a home program written especially for the use of the Rover Data Collecting System. This program will be responsible for the averaging of the maximum and minimum pressure values. Converting these values from a voltage to a pressure and then to its corresponding depth. The program will also have to store these depths and the intervals chosen between data points for the contour mapping and profile views which will be run off by the Docu-Map Program provided by the Morgan-Fairchild, Inc.. Once these maps have been produced final decisions can be made on when and where the proposed amphibious exercise will take place.

### Cost Analysis

<u>ITEM</u>	<u>COST</u>
Oceanographic Transducer (Teledynetaber)	\$1240.00
Inclinometer	\$ 495.00
2 Analog to Digital Convertors	\$ 10.00
8255 Interfacing Chip	\$ 4.95
Truck Odeometer	\$ 60.00
Container	\$ 210.00

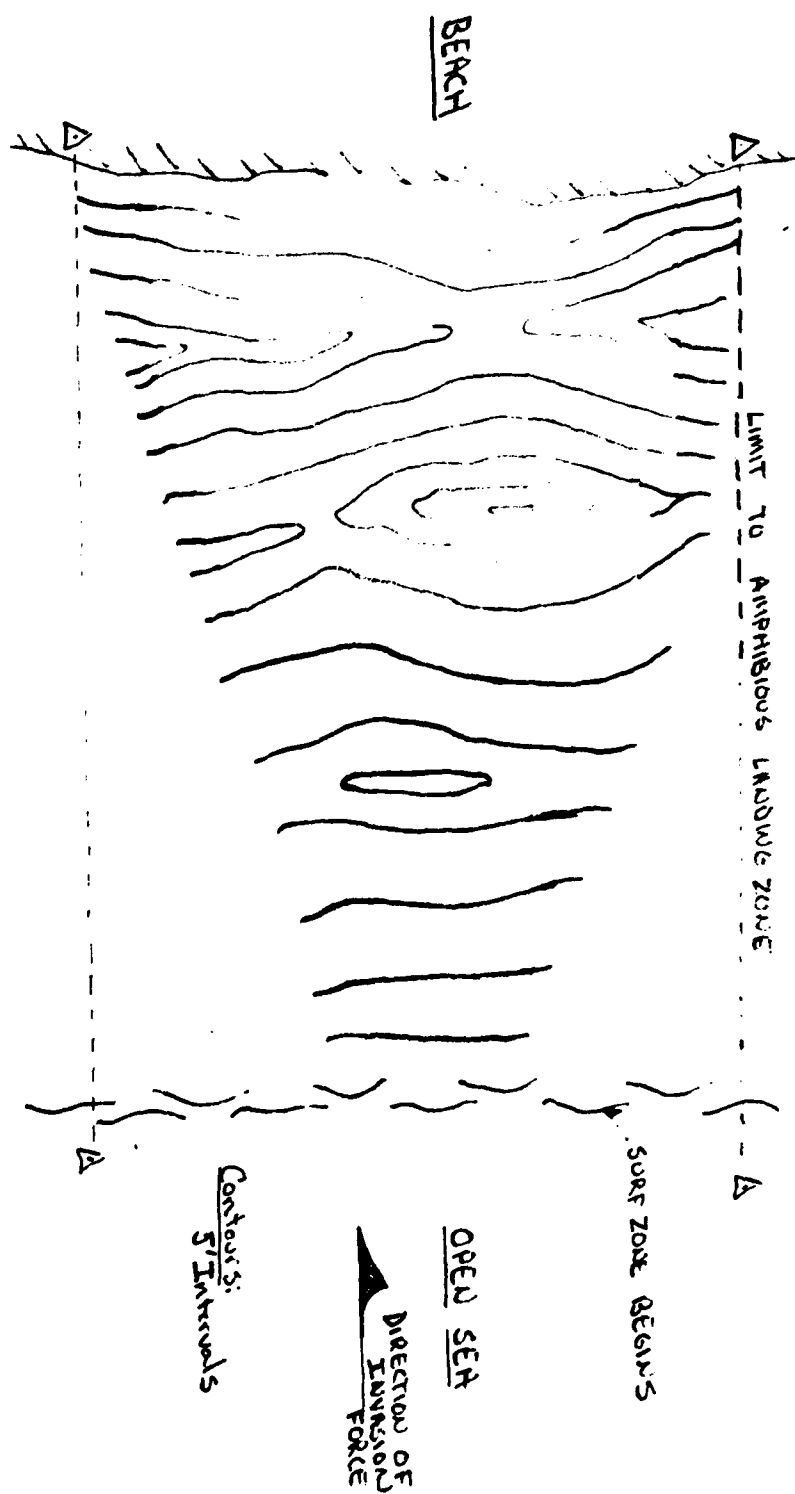
-  
Total= \$2019.95

Project Data Lines

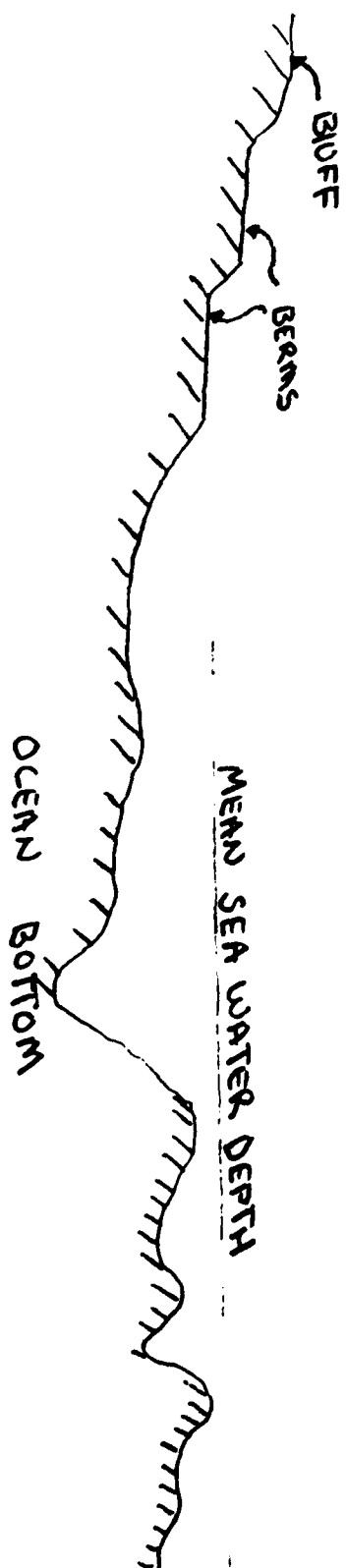


(Figure 1a)

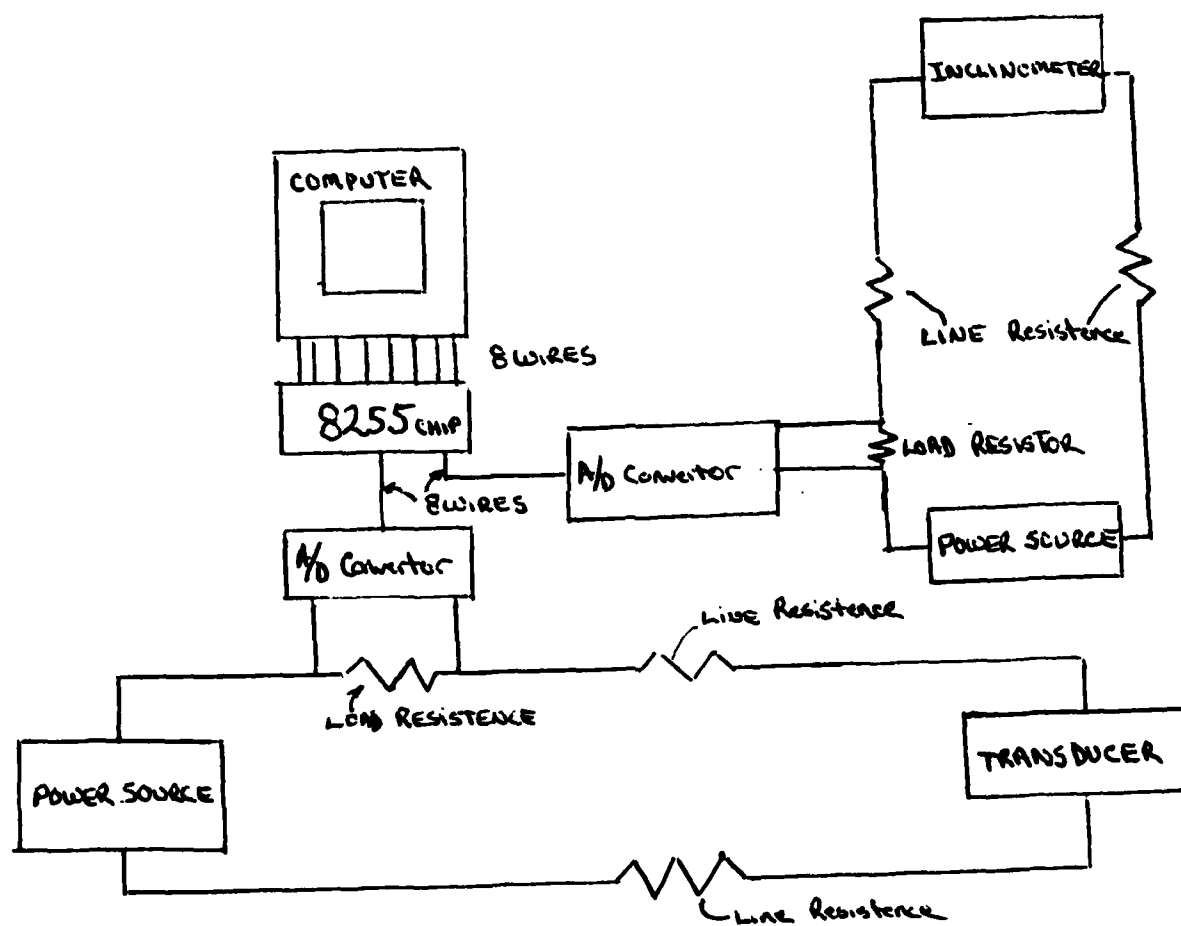
# Example of Docu-Map Contour Mapping



## Example of Profile Mapping



# Electrical Components of the Rover





### Conclusion

In conclusion the Bathymetric system we have designed provides an accurate, safe and reliable means of gathering information which is not present at this time. This system can replace the use of Navy Seals for such data collecting missions. Thus, the threat of loss of life has been eliminated. The accuracy of the data collected has increased. Plus the time to gather the information has been reduced considerably. This reduction in time and increase in data accuracy will insure that naval amphibious operations are performed without crucial delays.

### Recommendations

We would like to recommend that a prototype of this system be built and tested. This would provide information in determining if the logic used in our designing was correct. This prototype would also give important data which could help in redesigning if necessary. Plus it will most likely prove to be the logical choice for a needed bathymetric system. Our group feels that with the elimination of the possible loss of life in the Naval operations this system would be well worth its cost.

## SOURCES

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## FOOTNOTES

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<sup>2</sup>Shore Protection Manual, Vols. I and II. Vicksburg, Mississippi: Department of the Army. Waterways Experiment Station. Corps of Engineers. 1984, pp. 1.7 and 1.27.

<sup>3</sup>Miller, J.H. LTG, USMC. Intelligence FMFM2-1. USMC MODEL, Quantico. Va., p.17.39.

<sup>4</sup>Walker, Raymond, Capt. USMC. Personal interview.

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